

# **MARS GLOBAL SURVEYOR**

## **AEROBRAKING OPERATIONS DECISION PROCESS**

### **(AODP)**

**M. D. JOHNSTON**

# AEROBRAKING OPERATIONS DECISION PROCESS

---

## INTRODUCTION

- PROVIDES A FUNDAMENTAL FRAMEWORK TO FACILITATE FLIGHT OPERATIONS PLANNING AND DECISION MAKING DURING AEROBRAKING

=> SYSTEMS LEVEL VIEW OF AEROBRAKING OPERATIONS

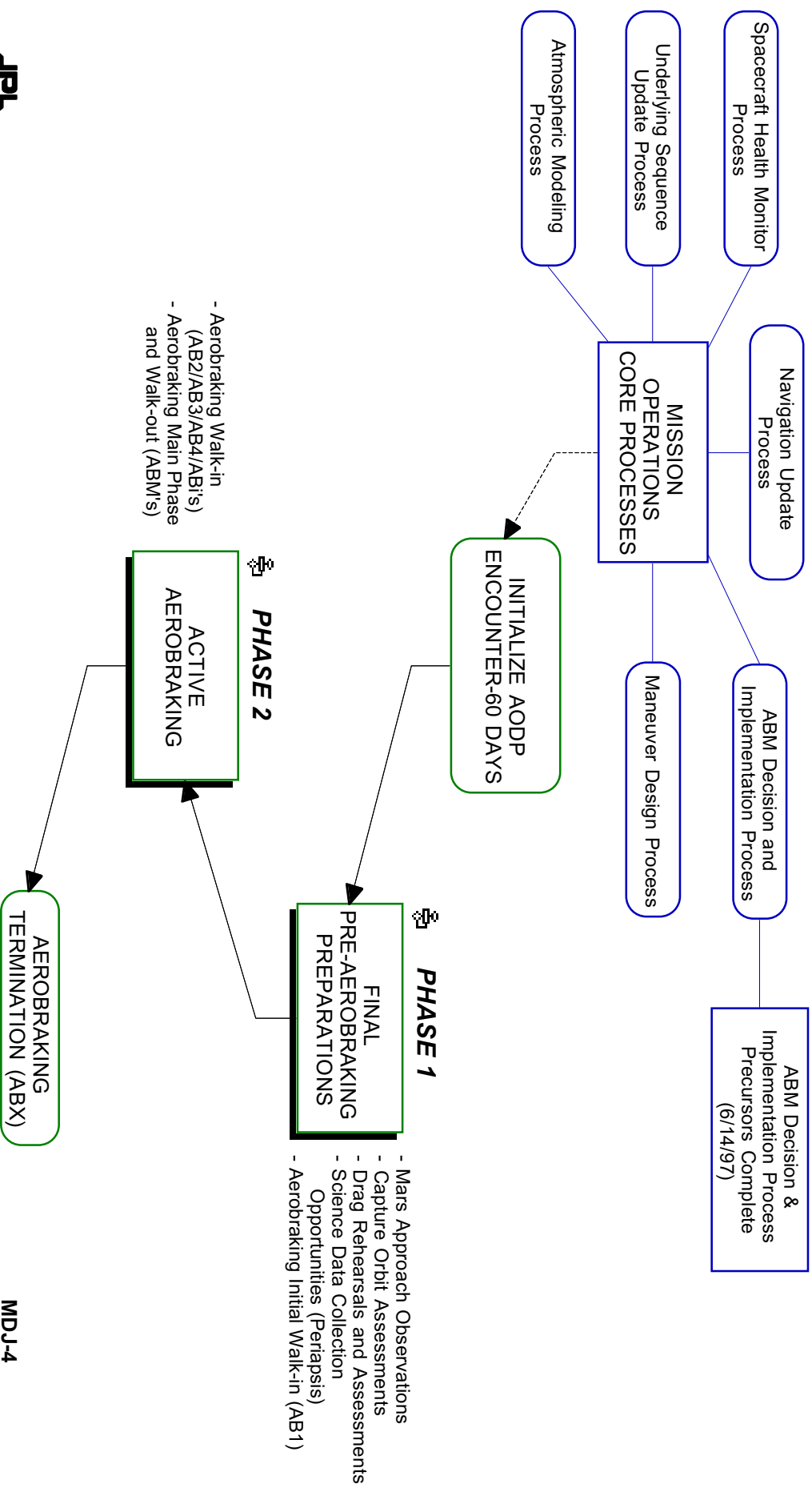
- BASED ON THE USAGE OF THE MISSION OPERATIONS SYSTEM (MOS) CORE PROCESSES
- ILLUSTRATES (AT THE PROCESS LEVEL) THE DATA PATHS AND FLOW NECESSARY TO SUPPORT AEROBRAKING OPERATIONS DECISION MAKING - SHOWS THE MOS PROCESS INTERACTION AS PARALLEL AND SERIAL ACTIVITIES
- IDENTIFIES KEY DECISION JUNCTURES THAT LEAD EITHER TO THE NEXT AEROBRAKING SUB-PHASE OR A PATH THAT MAY FORCE AN AEROBRAKING DELAY





# AEROBRAKING OPERATIONS DECISION PROCESS OVERVIEW

AEROBRAKING OPERATIONS DECISION PROCESS PROCESS OWNER  
=> MARS SURVEYOR OPERATIONS PROJECT (MSOP) FLIGHT OPERATIONS MANAGER <=



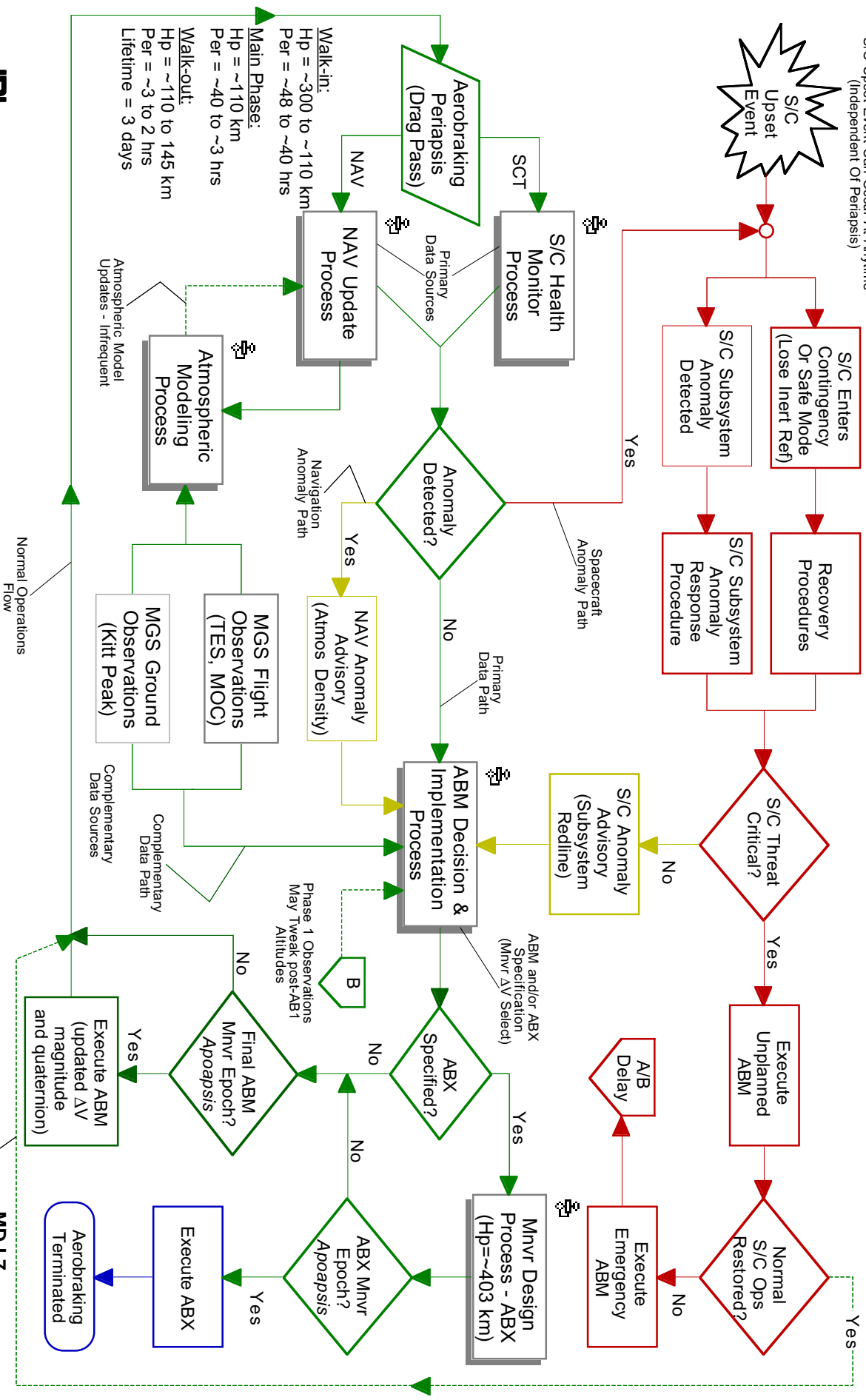




# AODP PHASE 2 - ACTIVE AEROBRAKING

## WALK-IN, MAIN PHASE, WALK-OUT

S/C Upset Event Can Occur At Anytime  
(Independent Of Periapsis)



## MISSION OPERATIONS CORE PROCESSES (1 OF 2)

---

- SPACECRAFT HEALTH MONITOR PROCESS
  - TO MONITOR SPACECRAFT HEALTH AND PREDICT SPACECRAFT PERFORMANCE
- NAVIGATION UPDATE PROCESS
  - TO GENERATED TRIGGER COMMANDS FOR SPACECRAFT DRAG PASS SCRIPTS AND TO GENERATE SPACECRAFT EPHEMERIDES
- UNDERLYING SEQUENCE UPDATE PROCESS
  - TO UPDATE SPACECRAFT SCRIPT INTERNAL TIMING DUE TO ORBIT PERIOD CHANGES AND TO COMMAND SCIENCE ACTIVITIES
- MANEUVER DESIGN PROCESS
  - TO DESIGN AND IMPLEMENT THE CRUISE TCM'S (TRAJECTORY CORRECTION MANEUVERS) AS WELL AS OTHER SELECT PROPULSIVE MANEUVERS (I.E. MOI, AB1, ABX, TMO, ETC.)



## MISSION OPERATIONS CORE PROCESSES (2 OF 2)

---

- ABM (AEROBRAKING TRIM MANEUVER) DECISION AND IMPLEMENTATION PROCESS
  - TO SELECT AND IMPLEMENT THE AEROBRAKING WALK-IN MANEUVERS POST-AB1 (AB2/AB3/AB4/ABi) AND TO SELECT AND IMPLEMENT THE NEXT ABM MANEUVER FOR CORRIDOR CONTROL MAINTENANCE
- ATMOSPHERIC MODELING PROCESS
  - TO UPDATE THE ATMOSPHERIC MODEL TO REFLECT CHANGING ATMOSPHERIC CONDITIONS AND TO BETTER UNDERSTAND ATMOSPHERIC BEHAVIOR

## AEROBRAKING OPERATIONS DECISION PROCESS

---

### PHASE 1 - FINAL PRE-AEROBRAKING PREPARATIONS

- *MARS APPROACH OBSERVATIONS*

PURPOSE: OBSERVE MARTIAN ATMOSPHERE DURING APPROACH

CHARACTERIZED BY: NOMINAL FLIGHT OPERATIONS COUPLED WITH THE INITIATION OF FLIGHT AND GROUND BASED OBSERVATIONS

TERMINATED BY: MOI MANEUVER

- *CAPTURE ORBIT ASSESSMENTS*

PURPOSE: DETERMINE CAPTURE ORBIT AND ASSESS SPACECRAFT STATE AS A RESULT OF THE MOI MANEUVER

CHARACTERIZED BY: NOMINAL FLIGHT OPERATIONS

TERMINATED BY: INITIATION OF THE SPACECRAFT DRAG REHEARSALS

- *SPACECRAFT DRAG REHEARSALS / INITIAL WALK-IN (AB1 MNVR DESIGN)*

PURPOSE: FINAL PREPARATIONS FOR AEROBRAKING

CHARACTERIZED BY: SPACECRAFT DRAG REHEARSAL AND ASSESSMENTS (MANEUVER SPACECRAFT TO THE AEROBRAKING DRAG ATTITUDE) AND SCIENCE DATA COLLECTION OPPORTUNITIES AT PERIAPSIS

TERMINATED BY: AB1 EXECUTION

## AEROBRAKING OPERATIONS DECISION PROCESS

---

### PHASE 2 - ACTIVE AEROBRAKING

- *WALK-IN (AB2/AB3/AB4/ABj)*

PURPOSE: CHARACTERIZE THE MARTIAN ATMOSPHERE DURING LATE SEPTEMBER / EARLY OCTOBER 1997

CHARACTERIZED BY: ESTABLISHMENT OF MARTIAN ATMOSPHERIC CONDITIONS THROUGH MULTIPLE REDUCTIONS IN PERIAPSIS ALTITUDE

TERMINATION CONDITION: ESTABLISHMENT OF MAIN PHASE NOMINAL HEATING RATES -  $Q\text{-DOT}_{\text{MAIN}} = 0.38 \text{ W/CM}^2$

- *MAIN PHASE (ABM'S)*

PURPOSE: LARGE SCALE REDUCTION OF THE ORBIT ENERGY

CHARACTERIZED BY: MAXIMUM NOMINAL SPACECRAFT HEATING RATES, INFREQUENT  $R_p$  LOWER (ABM) MANEUVERS, ARGUMENT OF PERIAPSIS DRIFTS TOWARD THE NORTH POLE ( $\omega = \sim 100.0$  deg at LP OPEN)

TERMINATED BY: ESTABLISHMENT OF A 3-DAY ORBIT LIFE TIME

- *WALK-OUT (ABM'S)*

PURPOSE: CONTINUED REDUCTION OF THE ORBIT ENERGY UNTIL PROPULSIVE MEANS CAN ESTABLISH THE MAPPING ORBIT

CHARACTERIZED BY: MAINTENANCE OF 3-DAY ORBIT LIFE TIME, REDUCTION IN THE SPACECRAFT NOMINAL HEATING RATES, DAILY  $R_p$  RAISE (ABM) MANEUVERS, ARGUMENT OF PERIAPSIS CROSSES THE NORTH POLE AND DRIFTS SOUTH

TERMINATED BY: APOAPASIS ALTITUDE = 450 KM,

DESCENDING NODE TIME = 2:00 PM

## AEROBRAKING OPERATIONS DECISION PROCESS

---

### RESPONSE TO MDT AI #41 (1 OF 2)

- MDT AI #41 - CLARIFY FLIGHT TEAM INVOLVEMENT IN THE AEROBRAKING OPERATIONS DECISION PROCESS (AODP) AND DEFINE TEAM INPUT PRODUCTS FOR THE AODP
- AODP HAS BEEN UPDATED -
  - REVISITED THE OVERALL AODP PROCESS FLOW
  - DATA PATHS AND DATA FLOW ARE CLEARLY DELINEATED
  - DECISION JUNCTURES NECESSARY TO SUPPORT FLIGHT OPERATIONS PLANNING HAVE BEEN CLEARLY IDENTIFIED
  - INTERCHANGE OF TEAM PRODUCTS AND THE ASSOCIATED DELIVERY FREQUENCY FOR 1) THE SPACECRAFT HEALTH MONITOR PROCESS, 2) THE NAV UPDATE PROCESS, AND 3) THE MANEUVER DESIGN PROCESS WERE PRESENTED AT THE MISSION SYSTEM CDR - BROOKS MOS PRESENTATION - 9/25/95 (NO CHANGE)
  - FORCED AEROBRAKING CONTROL PARAMETERS INTO THE ABM DECISION AND IMPLEMENTATION PROCESS (REMOVED FROM TOP LEVEL)

## AEROBRAKING OPERATIONS DECISION PROCESS

---

RESPONSE TO MDT AI #41 (2 OF 2)

RECOMMENDATION IS MADE TO CLOSE AI #41 WITH THE FOLLOWING PROVISO:

A) DETAILS OF THE ATMOSPHERIC MODELING PROCESS NEED TO BE WORKED (IDENTIFIED AT 2ND MGS MARS ATMOSPHERIC WORKSHOP - 6/18/96):

- 1) FLIGHT OPS ATMOSPHERIC MODEL UPDATE SUPPORT AND
- 2) ABM DECISION AND IMPLEMENTATION PROCESS SUPPORT

B) DETAILS OF THE AEROBRAKING CONTROL PARAMETERS (SPACECRAFT SUBSYSTEM AND TRAJECTORY) CONTAINED IN THE ABM DECISION AND IMPLEMENTATION PROCESS NEED TO BE WORKED (QUANTIFIED AND DOCUMENTED - APG OPS PROCEDURE)

1) AEROBRAKING WALK-IN SUB-PHASE

- ABI ( $i=2,n$ ) TARGET ALTITUDES AND MANEUVER FREQUENCY (RESPONSE TO ATMOSPHERIC SENSING (DENSITY OBSERVATIONS) AND STRATEGY FOR THE SELECTION OF THE NEXT ABI ALTITUDE STEP)

2) AEROBRAKING MAIN AND WALK-OUT SUB-PHASES

- CORRIDOR CONTROL LIMITS
  - $H_{PLow}$  - SPACECRAFT DYNAMIC PRESSURE AND HEATING LIMITS
  - $H_{PHigh}$  - "GLIDE SLOPE" (TRAJECTORY) PROFILE NECESSARY TO ACHIEVE 2:00 PM

## AEROBRAKING OPERATIONS DECISION PROCESS

---

- REQUIREMENTS FOR INITIATION OF AEROBRAKING OPERATIONS
  - NOMINAL FLIGHT PROFILE (AEROBRAKING REFERENCE TRAJECTORY) CONSISTENT WITH THE SPACECRAFT OPERATING ENVELOPE AND ACTUAL LAUNCH DATE
  - ABM DECISION & IMPLEMENTATION PROCESS PRECURSORS
    - SPECIFICATION OF  $\Delta V$  MAGNITUDE SETS
    - SPECIFICATION OF QUATERNION LOOK-UP TABLE PARAMETERS
      - FUNCTION OF EXPECTED ARGUMENT OF PERIAPSIS MOVEMENT DURING AEROBRAKING

- ABM CHARACTERIZATION

PLANNED ABM MANEUVER (ADVANCED OR FINAL) - NORMAL OPERATIONS

ADVANCED: MNVR EPOCH > 48 HOURS FROM EXECUTE

FINAL: MNVR EPOCH < 48 HOURS FROM EXECUTE

=> GENERATE S/C TRIGGER COMMANDS AND UPLINK

UNPLANNED ABM MANEUVER - RESPONSE TO A SPACECRAFT ANOMALY

=> AEROBRAKING IS SLOWED

EMERGENCY ABM MANEUVER - RESPONSE TO A MAJOR SPACECRAFT ANOMALY

=> AEROBRAKING IS DELAYED (POP-UP MANEUVER)

# AEROBRAKING OPERATIONS DECISION PROCESS

## SAMPLE ΔV MAGNITUDE AND QUATERNION LOOK-UP TABLE

~Five ΔV Magnitude Sets Necessary

Walk-inMain Phase - LateMain Phase - EarlyWalk-out

“Off-the-Shelf” Emergency Mnvr (Single Size)

One “Up” Quaternion Look-up Table and One “Down” Quaternion Look-up Table

ΔV Magnitude Set (m/s)					Up Table (Raise Periapsis)					ΔV Magnitude Set (m/s)					Down Table (Lower Periapsis)				
Half Size (1/2 X)	Full Size (1X)	Double Size (2X)	Arg Of Periapsis (deg)		Direction (Quaternion Table)					Half Size (1/2 X)	Full Size (1X)	Double Size (2X)	Arg Of Periapsis (deg)		Direction (Quaternion)				
0.5	1.0	2.0	150.0		up	q1	q2	q3	q4	0.5	1.0	2.0	150.0		dn	q1	q2	q3	q4
			140.0		.	.	.	.	.				140.0		.	.	.	.	.
			.		.	.	.	.	.				.		.	.	.	.	.
			.		.	.	.	.	.				.		.	.	.	.	.
			270.0		up	q1	q2	q3	q4				270.0		dn	q1	q2	q3	q4